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The Journal of HEREDITY

STERILE HYBRID MADE FERTILE BY COLCHICINE

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Plumage Dimorphism of the Pilgrim Goose

VOLUME 30 FEBRUARY, 1939 NUMBER 2

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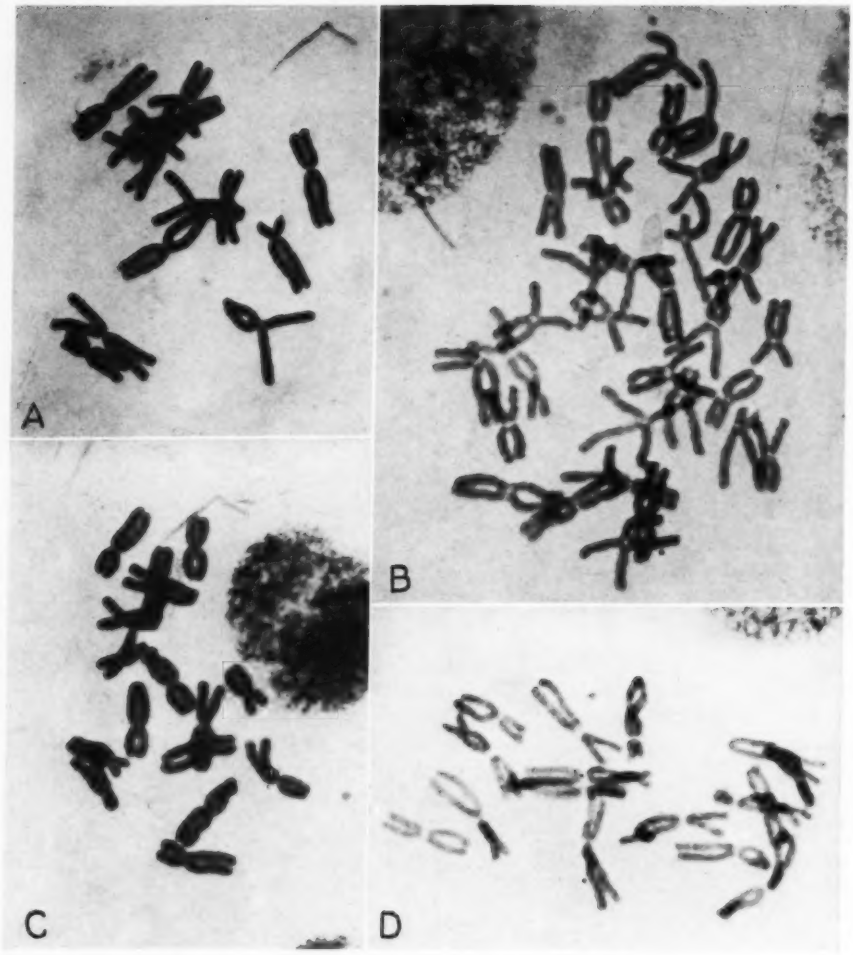

EFFECT OF COLCHICINE ON ONION CHROMOSOMES

Frontispiece

The figures here shown were all from cells of the same root, and were exposed to identical treatment. *A*—typical colchicine affected chromosomes in a cell containing 14 pairs. The lack of coiling and the size differences are apparent in the isolated chromosomes. *B*—A tetraploid cell (28 pairs) in which the chromosomes are very loosely attached at the insertion points, and presumably about to disjoin again. *C*—An affected cell in which the contraction has shortened the chromosomes far below their normal lengths. *D*—A cell which is but partially affected although division of the cell has been stopped. The coiling is still to be seen in some of the chromosomes. × 1000 (approximate).

OBSERVATIONS ON THE IMMEDIATE EFFECTS OF COLCHICINE

J. G. O'MARA*

DURING recent months reports have been accumulating which indicate that the efficacy of the drug colchicine in producing polyploid individuals is widespread among the higher plants.[1,6] Observations on the immediate effects of the alkaloid in cells and tissues are, however, not so numerous, and the present investigation was undertaken in an attempt to determine the nature of some of these direct results of application of the drug.

Materials and Methods

For the direct determination of the effects of colchicine on chromosome numbers and morphology, *Allium Cepa* was the experimental material used, and various confirmatory data were secured from *Triticum monococcum*, *T. vulgare*, and *Narcissus* sp. Rapidly elongating root tips, while still attached to the parental tissue, were subjected to various concentrations of the drug and durations of treatment, after which observations were made immediately and when periods for recovery in tap water had elapsed. Since one effect of the drug is to destroy completely the symmetry characteristic of dividing nuclei, sections through special planes were of little use in interpreting the conditions in the meristematic cells, and so aceto-carmine smears were used chiefly. The smears proved to have many advantages in addition to convenience, among which were the possibilities of flattening the preparations so that accurate length comparisons could be made, and of spreading the cell contents so that exact counts of chromosome numbers were feasible. However, for some purposes sections were useful, and each series of smears was supplemented by sections prepared in the usual manner.

Observations

The immediate result of the drug when used at concentrations above the threshold for effect is, as has been frequently described, the absence of all signs of the achromatic figure in cells which have the fully formed chromosomes characteristic of metaphase.[2,3,4,6,7] Immediately after, or parallel with, this cessation of division the chromosomes undergo a gradual contraction and thickening which causes the relational coils of the chromosome finally to be entirely lost, so that the half-chromosomes lie side by side attached at the insertion point only. Frontispiece *A* and *C* show these uncoiled chromosomes in diploid cells, and Frontispiece *B* shows a tetraploid cell in which many of the chromosomes have arms at right angles. If the treatment is continued, or if a residual from a previous treatment is present in the tissue, these chromosomes, after having contracted to various degrees, separate at the insertion region and lie in the cell apparently as single chromosomes tetraploid in number. However, some of the preparations indicate, by a fine line that runs irregularly the entire length of the chromosome, that before these half-chromosomes separate, the split for the second ensuing division is already present, so that the chromosomes may be considered at least double at this stage. Cells with chromosomes apparently single are much less common than with double, a situation which seems to indicate that once the disjunction occurs the split becomes

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rapidly apparent, being made more apparent than in normal chromosomes by the absence of the relational coiling which by holding the chromosomes together obscures the plane of separation. The cell, after such chromosome division without cell division, has the tetraploid number of chromosomes, and the subsequent divisions occur as the first, sometimes with further chromosome contraction, which is, however, not so marked as in the first instance. Frontispiece *B* shows a tetraploid cell in which the chromosomes are presumably about to separate further to again double the number. The number of divisions through which the complement may pass under the influence of the colchicine was not exactly determined since the chromosome numbers in cells more than octoploid are too high for precise counts—that more than three divisions occur can be exactly determined, and some preparations indicated that the complement had undergone five or six divisions. Cells with from 500 to 1,000 chromosomes have also been reported in Allium by Levan.[4]

The series which involved treatments for various periods at identical concentrations—one part in 10,000—indicated that the per cent of polyploid cells and the degree of polyploidy was directly related to the rate of growth of the root. From a single bulb which had a region of roots which grew more slowly than the others, 30 roots were treated for 24 hours. The 11 which came from the slower growing group had an average of but 39 metaphases to a smear, while the 19 from the faster group had an average of 203 metaphases, many of which were polyploid. The drug manifested itself by altering chromosome structure after as few as three hours, and after 15 hours one smear had 197 metaphases, another 204, and a third 251, and the three smears had an average of 47 of the metaphases polyploid. After a full day in the solution many average roots had as many as 50 per cent of the metaphases in the polyploid condition. However, in very few preparations were normal appearing chromosomes completely absent. Since the effect of the drug is the accumulation of metaphases, and not stimulation,[6] the number of metaphases and the per cent of polyploid cells should be related to the rate of division, or the number of metaphases which would normally occur during the period of treatment. These data apply to *Allium* only, and the times and concentrations for *Triticum* and *Secale* were found to be quite different.

In addition to induction of polyploidy, several other phenomena of interest were associated with colchicine treatments. The examination of root tips subjected to an extensive series of concentrations which were known from previous work to lie in the region of minimum dosage for recognizable effect, showed that for these tissues there is no exact threshold for effect on the achromatic figure. The concentrations which suppressed cell division partially lay approximately between one part in 10,000 and one part in 20,000—in solutions weaker than the latter, affected cells are very rare, and in solutions stronger than the former, the chromosomes start to show the severe contraction associated with strong doses of the drug. However, in the intervening region, both types of cells are found in the same treated tissues. Some cells have the contracted chromosomes typical of heavy doses of colchicine, and others have chromosomes which are at metaphase but still partially coiled (Frontispiece *D*), while still others show no effects at all. Since this situation, where normal and affected chromosomes were found in the same tissue, was observed in root tips which had been treated for as long as 72 hours, it could not be attributed to different concentrations which had come about as a result of the diffusion of the drug inwards. A search for conditions which might be considered between division and non-division of the cell was made without finding such conditions, although they may exist. This fact would seem to indicate that for single cells a definite threshold exists in this material. Some intermediate conditions, which were observed during recovery, have been reported by Levan.[4] Frontispiece *A*, *B*, *C*, and *D* are of cells from

the same root, and show the various appearances of cells treated in identical fashion. The data would seem to indicate that cells which appear to be identical components of meristematic tissue may have significantly different resistances or reactions to the drug.

The macroscopic effect of the colchicine is, as has been described,[1,2,4] the production of tissues which differ markedly from normal ones in that they appear stunted and leathery. Cotyledons and hypocotyls are dwarfed, and irregular in texture. In Allium root tips there appears after a day of treatment a swollen region just behind the meristem, and as the treatment continues this region increases in diameter, until after several days it has a diameter of several times that of the normal root at that place. This swelling Levan has stated to be the result of increased chromosome numbers which cause the cell to swell in accommodating them. The present observations on sectioned material indicate that this hypertrophy is not in the region of division, but in the region of elongation, and that the component cells are not meristematic in appearance or location, but have the large vacuoles and comparatively small nuclei of elongating and differentiating cells. This observation is given further confirmation from treatments involving grasses in which the coleoptile was made to show an identical effect. Since growth in the coleoptile is by elongation, these swellings could hardly be the result of polyploidy. Bulbs of Narcissus were also induced to produce hypertrophied peduncles in the elongating region. The effects already reported on cotyledons are most probably effects on maturing rather than on dividing cells.

In the material treated with effective concentrations of the drug, and crushed and stained as in the aceto-carmine technique, the size differences which exist among the members of the chromosome complement are easily measurable, if the chromosomes have not been allowed to shrink so far that such differences are obscured. In Frontispiece *C* the contraction has persisted to such a degree that the differences in length are not so apparent as in Frontispiece *A* and *D*, where the differences are readily noticeable. As a method of studying the morphology of somatic chromosomes, colchicine treatment yields results far superior either to sections or to ordinary smears in that they uncoil the chromosomes, and spread them throughout the cell where they may be more easily observed and measured than when closely aggregated into metaphase plates. The present figures show that the size differences sometimes reported for Allium chromosomes have been exaggerated, perhaps by optical foreshortening of the smallest chromosomes.

Summary

Observations on the effects of colchicine treatments for different periods and concentrations are recorded. The hypertrophy usually associated with treatment was found not to involve the meristem but the region of elongation. The colchicine-affected chromosomes are more accurately measurable than ordinary somatic chromosomes — this may indicate that the drug can be profitably used in studies of chromosome morphology in somatic tissues.

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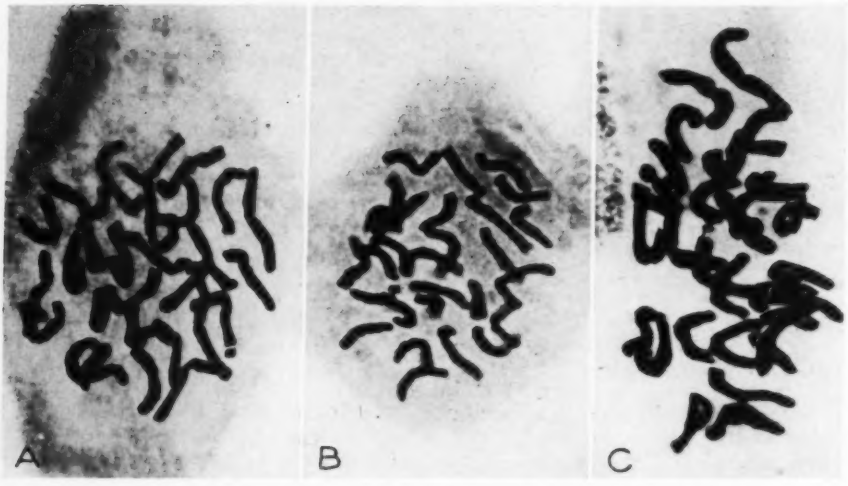
AMPHIDIPLOIDS IN THE *TRITICINAE* INDUCED BY COLCHICINE

E. R. SEARS*



CYTOLOGICAL EVIDENCE OF CHROMOSOME DOUBLING

Figure 1

Photomicrographs from root-tip smears of three amphidiploids, all showing 28 chromosomes. These arose from sterile species crosses having 14 chromosomes. (A) *T. monococcum* × *Ae. uniaristata;* (B) *Ae. caudata* × *Ae. umbellulata;* (C) *Ae. speltoides* × *Ae. umbellulata.* (A) and (C) retouched. × 1150.

FOR a study already in progress on polyploidy in the Triticinae, several amphidiploids involving species with the basic chromosome number of this group ($n = 7$) were desired. The following is an account of the production of three such amphidiploids through the use of colchicine. Several investigators[1, 2, 3, 4, 9, 10, 11, 13] have reported tetraploid plants obtained through colchicine treatments, but no one has previously recorded successful use of the drug in producing polyploid grasses.†

Materials

Seeds of 29 different kinds of 14-chromosome ($2n$) hybrids were treated with colchicine. In 10 of these 29 families, no seeds survived the treatment. Of the 19 families in which one or more seeds did survive, 12 were interspecific hybrids within the genus Aegolips, and 7 were intergeneric hybrids of *Triticum monococcum* and *T. aegilopoides baidaricum* with Aegilops species and with *Haynaldia villosa.* All plants produced from the

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†Dr. W. M. Myers of the United States Regional Laboratory for Pasture Research, State College, Pennsylvania, kindly allows me to note that he has induced with colchicine a number of tetraploids of *Lolium perenne.* His results are soon to be published.

A FERTILE GENUS HYBRID

Figure 2

Spikes of parents, sterile F_1 and fertile amphidiploid F_1 of *T. monococcum* × *Ae. uniaristata*. The 4*n* spike is from a different F_1 plant than the 2*n* spike, and is mature, whereas the 2*n* and parent spikes are in flower. The seeds shown are part of those harvested from the amphidiploid × 4/7.

treated seeds were completely sterile, except for the tetraploid sectors.

Methods

In accordance with the recommendations of Dr. J. G. O'Mara, germinating seeds were immersed in an aqueous solution of colchicine for about 24 hours, then soaked in water for about six hours. The concentration of colchicine was one part in 2000, except that a few seeds of *T. monococcum* × *Ae. uniaristata* were treated with one part in 1000.

As far as possible, treatments were given when the coleoptile had just broken through the testa, this stage being reached in from one to six days at room temperature after an initial one-day period at about 5° C.

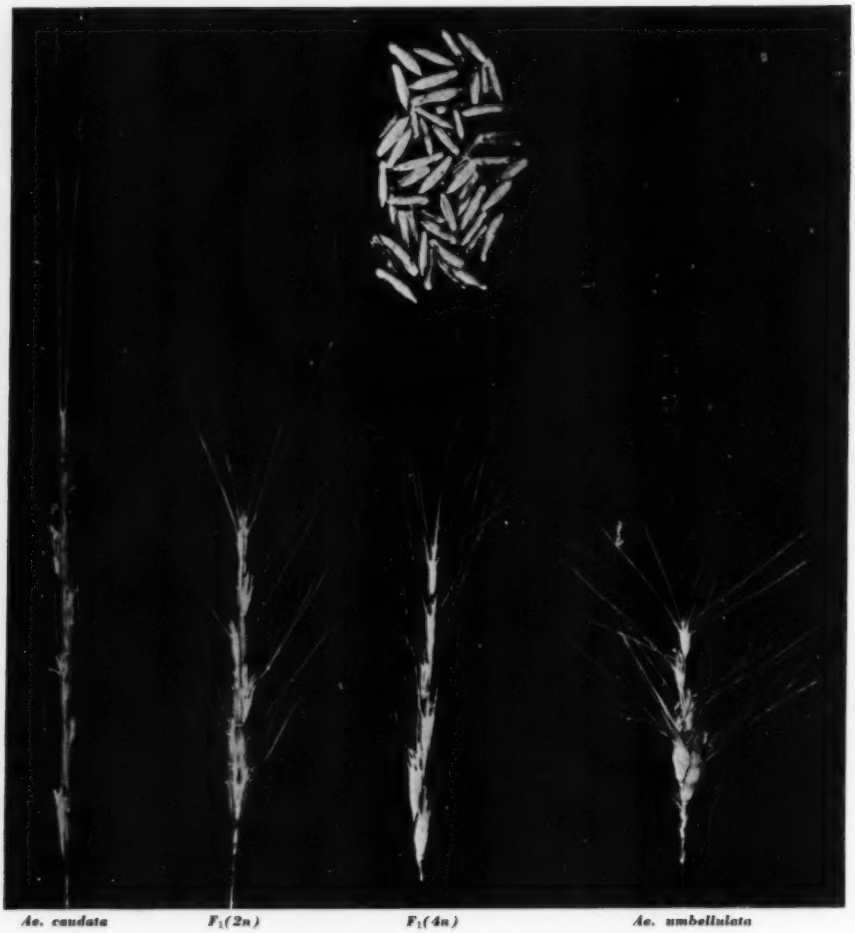
Results

From 177 treated seeds of 29 different hybrids, 46 mature plants were obtained, representing 19 hybrids. Five of the 46 plants had amphidiploid sectors, one of the five being *T. monococcum* × *Ae. uniaristata*, two being *Ae. caudata* × *Ae. umbellulata*, and two being *Ae. speltoides* × *Ae. umbellulata*. These three families, which came from 26, 5, and 19 seeds, respectively, contained two, five and four mature plants, including the affected ones. The affected plant of *T. monococcum* × *Ae. uniaristata* was one which survived from 10 seeds treated with one part of colchicine in 2000. The unaffected plant in this family came from 16 seeds treated with one part in 1000.

Except for the *Ae. caudata* × *Ae. umbellulata* plant which bore the single seed (Table I), the amphidiploid condition of each fertile sector was verified by growing from two to four of the seeds produced on the sector and counting the root-tip chromosomes. In every case the number was 28 (Figure 1).

One of the amphidiploids, *Ae. speltoides* × *Ae. umbellulata*, has already been obtained by Kihara.[6] The other two are reported here for the first time. Figures 2 to 4 show spikes of the three amphidiploids, of the hybrids from which they were obtained, and of the parents.

The tetraploid sectors were much larger than those which other investigators have found in untreated material. Table I shows that as much as one-third of a plant was affected, as calculated from the number of sterile and fertile spikes on the first main crop of tillers. The fertile tillers comprised a definite sector in each case. Naturally occurring amphidiploid sectors, according to W. J. Sando (Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, Washington, D. C., verbal communication), who has observed their occurrence in several different hybrids of wheat and its relatives, have not involved as much as a whole head—usually only a few florets. In the colchicine-treated material there were three heads (all on the two affected



FERTILITY THROUGH CHROMOSOME DOUBLING

Figure 3

Spikes of parents, sterile F_1, and amphidiploid F_1 of *Ae. caudata* × *Ae. umbellulata*. Although from the same plant, the $2n$ F_1 spike was photographed at flowering, the $4n$ at maturity. Some seeds from the amphidiploid sector are shown. No seeds were produced by the $2n$ sector. × 6/7.

plants of *Ae. speltoides* × *Ae. umbellulata*) which were part sterile and part fertile. The fertile portion of each head included two or three spikelets on the same side of the rachis. These chimeral tillers were presumably on the edge of the tetraploid sector. A secondary tiller produced on one of them was completely sterile.

Sixteen untreated plants of *T. monococcum* × *Ae. uniaristata* were available as a control for the treated plants of that hybrid. None of these had a fertile sector.

TWO AMPHIDIPLOIDS FROM ONE CROSS

Figure 4

Spikes of parents, sterile F_1, and amphidiploid F_1 of *Ae. speltoides* × *Ae. umbellulata*. The 4*n* spikes (third and fourth from left) were mature when photographed, while the others were flowering. Although the parentage of the two amphidiploids (1790-1 and 1790-2) was identical, the former plant, in both its fertile and sterile portions, had longer spikes than the the latter (see Table 1). The two groups of seeds are from the respective amphidiploid sectors × 3/4.

The five plants with tetraploid sectors were confined to three of the 19 families, and these families contained only 11 of the 46 treated plants. This tendency of the colchicine treatments to induce tetraploidy in only certain of the families can be correlated to some extent with differing susceptibilities among the hybrids to the concentration of colchicine used. Seedlings of some families, although they received the same treatment as the rest, failed to develop the hypertrophy of the coleoptile which characterized seedlings of all the families which later were to show tetraploidy. Some families developed the hypertrophy but later showed no tetraploidy. These may have been treated at an improper stage or for too short a time, or the families may simply have been too small to include affected plants.

All of the amphidiploids are free-

seeded, whereas *Ae. caudata, Ae. speltoides,* and, to a slight extent, *Ae. uniaristata,* have clinging inner glumes.

Spikes of *Ae. caudata, Ae. umbellulata,* and *Ae. uniaristata* are fragile at the base when mature, while those of *Ae. speltoides* and, to some extent, those of *T. monococcum* are fragile at every node. *T. monococcum* × *Ae. uniaristata* amphidiploid resembles the *Aegilops* parent in being fragile at the base. *Ae. speltoides* × *Ae. umbellulata* amphidiploid differs from both parents in being practically non-fragile (only slightly so at the base).

Cytological data on the three hybrids which gave rise to amphidiploids are summarized in Table II. The data parallel fairly closely those of Sorokina[12] on *Ae. caudata* × *Ae. umbellulata* and Kihara[6] on the same hybrid and on *Ae. speltoides* × *Ae. umbellulata.* The main difference is in the number of trivalents, which is higher here than Kihara found, particularly for *Ae. speltoides* × *Ae. umbellulata.* When the frequency of univalents in the hybrids is compared with the pollen fertility of the amphidiploids (Table I), a high positive correlation is found. This means that less chromosome pairing in F_1 resulted in greater fertility in the amphidiploid.

No morphological differences could be discovered between the 2*n* and 4*n* tillers of any of the five affected plants, except for a possible slight tendency toward greater width of outer glumes. No difference was found in length of head or in total length of tiller. Stomata of the 4*n* leaves were larger and farther apart than those of 2*n* leaves, except for *T. monococcum* × *Ae. uniaristata,* whose 4*n* stomata were apparently of the same size and distribution as its 2*n* stomata.

The *Ae. caudata* × *Ae. umbellulata* amphidiploid is of particular interest because of the observations of Sorokina,[12] who found the diploid hybrid to be morphologically indistinguishable from *Ae. triuncialis typica* ($n = 14$), although its chromosomes were more like those of *Ae. persica.* The amphidiploid will furnish a means for testing these chromosome homologies.

Kihara[6] has obtained tetraploids of *Ae. speltoides* × *Ae. umbellulata* from untreated hybrids. It is possible that part or all of these are not true amphidiploids, however, since they originated through the union of gametes from the diploid hybrid. Such gametes may have the somatic number without containing the exact somatic complement of chromosomes, as has been shown by Kihara and Nishiyama,[7] Kostoff,[8] and Howard.[5] One or more of the following abnormalities may be present: (1) *deficiency* for all or part of one or more chromosomes, (2) *duplication* for all or part of one or more chromosomes, and (3) one or more *segmental interchanges.*

Table I. Size and fertility of amphidiploid sectors.

	Designation of Plant	Approximate Proportion of Plant Fertile	No. Spikes Harvested	No. Functional Spikelets per Spike	No. Seeds per Spike		Approximate Pollen Fertility in Per Cent
					Ave.	Range	
T. monococcum × Ae. uniaristata	1070.2	1/4	11	8-10	10.4	7-13	95
Ae. caudata × Ae. umbellulata	1901-2	1/7	14	6	8.1	5-11	80
	1901-1	1/20	1	8	1	1	
Ae. speltoides × Ae. umbellulata	1790-2	1/4	16	7-8	8.9	6-13	70
	1790-1	1/5	15	10	7.4	1-17	

Table II. Meiotic behavior of the three hybrids from which amphidiploids were obtained.

	No. Cells Examined	Univalents per Cell		Open Bivalents per Cell		Closed Bivalents per Cell		Trivalents per Cell	
		Range	Ave.	Range	Ave.	Range	Ave.	Range	Ave.
T. monococcum × Ae. uniaristata	100	8-14	10.18	0-4	1.84	0-1	.02	0-1	.03
Ae. caudata × Ae. umbellulata	80	8-10	8.64	1-3	2.46	0-1	.13	0-2	.40
Ae. speltoides × Ae. umbellulata	80	1-7	3.22	1-6	3.02*			0-3	1.80

*Includes one tetravalent, computed as two bivalents.

Summary

In sterile hybrids of *Triticum monococcum* × *Aegilops uniaristata, Ae. caudata* × *Ae. umbellulata,* and *Ae. speltoides* × *Ae. umbellulata,* amphidiploid sectors, involving up to one-third of the plant, occurred as a result of colchicine treatments administered to the hybrid seedlings. These sectors were male and female fertile, the height of pollen fertility of the different amphidiploids varying inversely with the degree of pairing in the corresponding diploid hybrids. Little or no morphological difference was found between 2*n* and 4*n* tillers of the same plant, and *T. monococcum* × *Ae.*

uniaristata even failed to show a difference in stomatal size or distribution.

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WHAT WE KNOW ABOUT CANCER

THE symposium at Wisconsin was planned, according to the preface,* "because cancer has created an important social and economic problem with reference to the medical care of the sick; because its cause, cure, prevention, and control is given so much attention by the press; because various sciences have contributed to the modern concept of cancer and because this concept is of primary importance in the organization of methods of treatment, research, and the selection of material for public educational programs." "The program was organized, broadly speaking, for the discussion of cancer and inheritance, the biology of the cancer cell, cancer as a public health problem, and the etiology of cancer. It was arranged for the presentation of prepared addresses and the conduct of round tables for the discussion of problems of interest to those engaged in special fields of research and clinical medical practice."

The book is made up of short papers by (1) Leiv Kreyberg, Det Norske Radium Hospital, Oslo, Norway, (2) Clarence C. Little, Director of the Roscoe B. Jackson Laboratory for Cancer Research, (3) Madge Thurlow Macklin, University of Western Ontario, (4) Edgar Allen, Professor of Anatomy, School of Medicine, Yale University, (5) Howard B. Andervont, U. S. Public Health Service, (6) James Ewing, Professor of Oncology, Cornell University Medical College, (7) Gioachino Failla, Memorial Hospital, New York, (8) Henri Coutard, Chief of the Department of X-ray Therapy, Curie Institute, Paris, (9) Warren H. Lewis, Carnegie Institution of Washington, (10) Stanley P. Reimann, Lankenau Hospital, Philadelphia, (11) James B. Murphy, Rockefeller Institute for Medical Research, New York, and (12) Emil Novak, Johns Hopkins Medical School.

A review of this length cannot include all the items that may be of interest to our readers. Among others may be mentioned that the chapter by Professor E. Allen reviews the work on the influence of estrogens on the stimulation of atypical and malignant growths in experimental animals. The growth stimulating properties of estrogens were particularly stressed. The uniformity and individuality of each of several different sarcomas grown for many generations in vitro or in vivo was stressed in a chapter by Dr. W. H. Lewis. "The malignant cells of the different sarcomas so far studied differ visibly from any normal cells appearing in cultures and from one another. The cells maintain their peculiar visible cytological characteristics as well as their malignancy in vivo — and in vitro —."

**A Symposium on Cancer.* University of Wisconsin Press, Madison, 1938. The brochure contains seventeen articles presented before the Cancer Institute of the University of Wisconsin under the auspices of the School of Medicine, September 7-9, 1937.

The difficulties in intelligently diagnosing early or precancerous changes of the cervix and the methods used in diagnosing such changes (colposcopy-Schiller tests) were discussed by Dr. E. Novak. Treatment was briefly discussed. Bowen's disease was particularly considered to be early cancer while leukoplakia in its milder forms exhibited no macroscopic evidence of malignancy. Dr. Henri Coutard in discussing treatment of tumors of the breast divided them into three groups. One group, metastasizing early and readily through the lymphatics, responded readily to X-ray therapy. A second group metastasizing late and intravascularly responded poorly to X-ray therapy and are favorable cases for surgery. A larger third group of breast tumors showed medium radio-sensitivity.

Dr. James B. Murphy developed the conclusion that "there seems to be no doubt that a virus may under certain conditions act as an incitor of malignancy, as is illustrated by the Shope virus, but so far as mammalian tumors are concerned, there is no evidence that a virus is involved in the essential process. In other words, they may act as carcinogenic agents and as such play a part in the causal genesis but not in the formal genesis of tumors. It is not unlikely that in the human being there exist pathological conditions similar to the rabbit papilloma, where the initiator of the process leading to malignancy is a virus."

Dr. H. B. Andervont has, very capably, presented two chapters on cancer research. In the first one, he discusses the present knowledge of the chemistry of the carcinogens; in the second, the effects of bacterial products on tumor tissue.

The material that is of more than passing interest to students of heredity is contained in six chapters, written by Reimann, Macklin, Little, and Kreyberg. Dr. Reimann concludes that "the growth and development of organisms take place as a whole, by the growth in mass, differentiation into cells, specialization, and integration of protoplasm. The growth and development of the protoplasm of cancer is not under the influence of the organism as a whole, as is manifested by at least a partial lack of differentiating abilities, and by the entire lack of organizing properties." Dr. Macklin reiterates her belief in an inheritance of cancer susceptibility in human beings. Her reasoning is based primarily upon the statistical analysis of probabilities. In order to strengthen her position in the inheritance of cancer susceptibility, she discounts present conceptions of a correlation between chronic irritation and cancers. As yet it has not been definitely proven.

Dr. Little, after re-stating his earlier critcism of the genetic work of Maud Slye, very carefully presents his present conception of the rôle of intrinsic factors on the development of tumors in mice. This conclusion is stated as follows, "The process of carcinogenesis then becomes one in which there are three variables: (1) the genetic constitution of the tissue affected; (2) the internal environmental conditions, such as sex, physiological age, and similar influences exerted as indirect factors which affect the biological surroundings where cancer may develop; and (3) some physiologic unbalance or irritation caused by hypo- or hyperfunction of tissues or experimentally introduced by the application of chemical or physical agents for that purpose."

A broad concept of the place of genetics in the field of cancer research is presented, in the first and in the last chapters of the book, by Kreyberg. The first chapter is on "The Genetic and Constitutional Aspects of Spontaneous and Induced Tumors," the last one is entitled, "The Influence of Extrinsic Factors on the Development of Induced Tumors in Animals."

The book should be of interest to all students of oncology as well as to biologists in general and to geneticists in particular.

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THE INHERITANCE OF MELANISM IN PHEASANTS

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LITTLE is known relative to the genetics of the genus Phasianus, or true pheasants. This genus includes the so-called common pheasants which play an important part in our upland game bird shooting as well as a number of the "fancy" pheasants of the aviary. Information concerning the genetics of these birds would be important from the practical point of view as well as from the standpoint of its contribution to comparative genetics within the family *Phasianidae*, which includes the domestic fowl and turkey.

According to Beebe[1] there are two distinct species of true pheasants, *Phasianus versicolor* and *P. colchicus*. Under the former there are four and under the latter twenty-three subspecies. The two species are interfertile. The plumage of *versicolor* is predominantly green, whereas in *colchicus* red, yellow and brown predominate. The native habitat of *P. versicolor* is the islands of Japan while *P. colchicus* is found scattered over many parts of continental Asia as well as on the island of Formosa.

Peters[18] groups all "true" pheasants under the species *colchicus* and, differing from Beebe, classifies the *versicolor* as one of the forty-two subspecies. The author of this paper believes that Peters is the more nearly correct in his classification although it is possible that some of the races listed are not entitled to subspecific rank. However, in order to avoid confusion in discussing previously reported work, the older method of classification, *i.e., P. versicolor* rather than *P. c. versicolor,* is used in this article.

The common ringneck pheasant (Figure 5*A*) of the United States is a mixture of three subspecies of *P. colchicus* : *P. colchicus colchicus* (Caucasian or English), *P. c. torquatus* (Chinese) and *P. c. mongolicus* (Mongolian).

There is one pheasant which has not been definitely accepted as belonging to any of the above species or subspecies, but which Hachisuka[8] has tentatively called *P. colchicus* mut. *tenebrosus*. This is the form known to pheasant breeders as the "melanistic mutant" or black pheasant (Figure 5*B*), which has been stocked for hunting purposes in some states and is common in the aviaries of fanciers.

Pheasants of different genera and species have been used in crosses and other experiments by a number of investigators, but very little attempt has been made to analyze the genetic bases for the complex color variations found in the plumage of this group. In most cases intergeneric crosses were used and the resultant sterility of the F_1 generations prevented further analyses. Thus very little information on the genetics of the pheasant is available.

Data on the inheritance of plumage color in Phasianus are reported by Phillips,[19] who found that following a cross, pied male $\times$ ringneck female, pied plumage was recessive to the normal. In this cross the F_1 were all of the ringneck plumage color, whereas in the F_2 there were 62 ringnecked and 22 pied with no sign of sex linkage. The gradation in the pied birds was extreme, ranging from almost white individuals to those showing only a small amount of white. Phillips states that Cronan[2]

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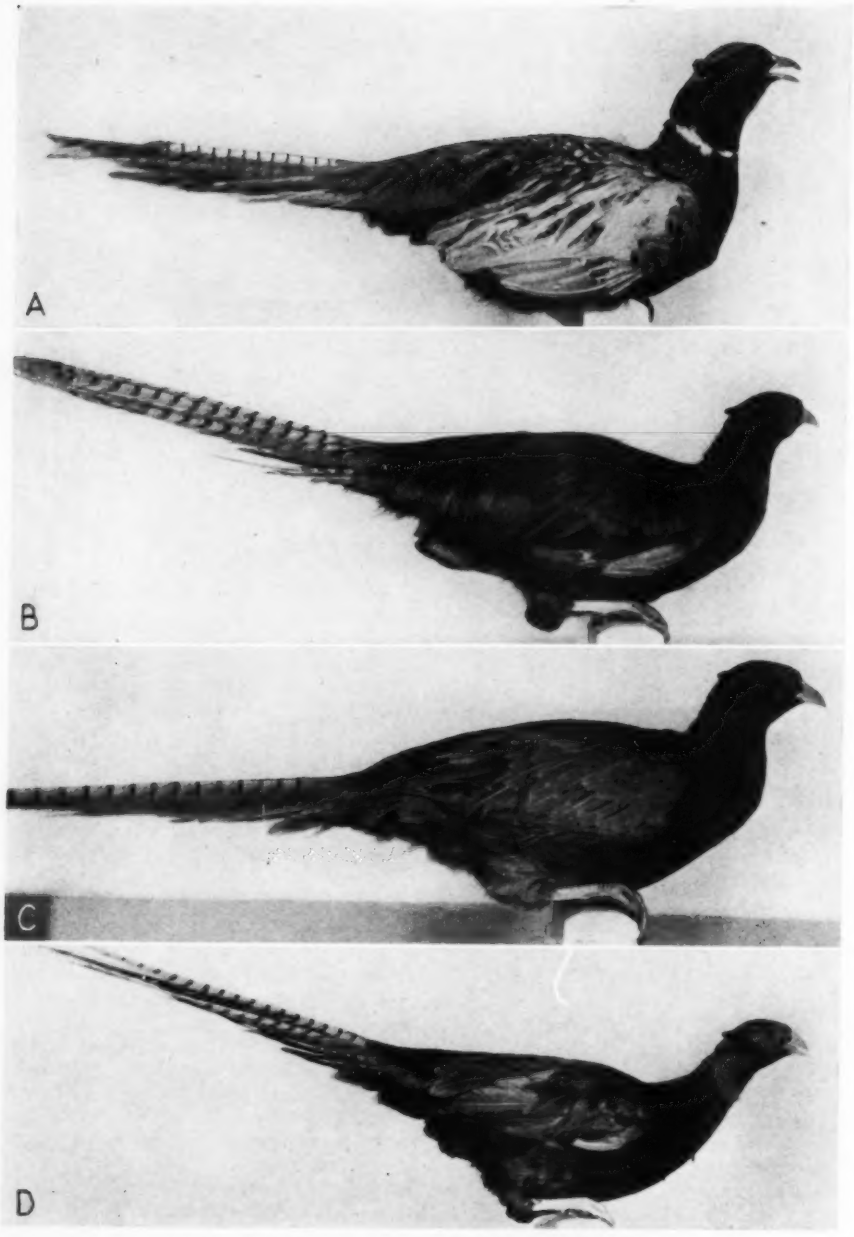

"NORMAL" AND MELANISTIC PHEASANTS

Figure 5

A—Common Ringneck pheasant male (*Phasianus colchicus*). *B*—Melanistic pheasant male B-60. This bird was three years old when the photograph was taken and fading of the plumage is evident. *C*—F_1 male ex Ringneck × Melanistic. This bird is similar in feather pattern to the Versicolor pheasant although this particular specimen does not show the light wing coverts. *D*—Backcross male (F_1 female [Ringneck × Melanistic] × Melanistic male B-60). Note absence of markings as compared to (*C*).

found white in pheasants to be entirely recessive but no data are given.

Haig-Thomas[12] crossed a *P. versicolor* male with *P. colchicus formosanus* females. The hybrids were intermediate and in the backcross of the females to the versicolor male, the five female progeny resembled versicolor and the two males were similar to the Formosans, although there was a blending of color and pattern in both sexes.

The Melanistic Mutant

The origin of the melanistic form of Phasianus is apparently unknown although it has been the subject of numerous discussions. MacIntyre[16] states that the melanistic form was first described in England by Lord Rothschild in 1888. The author does not have access to the original paper.

The main point of contention is whether this bird is a true mutation or is the result of selective breeding after crosses of the two species, *P. versicolor* and *P. colchicus*, had been made. Both theories have supporters but to the best of the writer's knowledge no conclusive experimental data have been obtained. Hachisuka[8] believes that this form is a true mutation, and, accordingly, calls it *P. colchicus* mut. *tenebrosus*. Seth-Smith[20] and Delacour[6] are of the same opinion. Many game breeders, however, think that this bird is the result of selection after various crosses have been made. This view is shared by Lowe[14,15] and Haig-Thomas[13]. The supporters of this theory are of the opinion that *P. versicolor* was used in the original crosses but are not certain as to the other parental race. *P. colchicus colchicus* and *P. colchicus torquatus* are generally accepted.

It has been reported that *P. versicolor* was introduced into England in 1840.[7] The date of introduction of *P. colchicus colchicus* is unknown, but it goes back at least to 1059.[5] How soon the versicolor pheasant was placed in the coverts is unknown, but Tegetmeier[21] states that hybrids of *P. versicolor* and *P. c. colchicus* were shot as early as 1853 and that hybridization had occurred somewhat earlier. The total number of versicolors introduced was small and apparently the infusion of this blood soon disappeared.

Beebe[1] has described the various subspecies of Phasianus in his monograph, but no mention is made of the melanistic form.

Descriptions in various journals and photographs of museum specimens make it apparent that the melanistic form of today differs from the earlier type in that the early-day melanistic pheasant carried more markings and exhibited less melanism than does the pure melanistic pheasant of today.

Through interviews and correspondence with various game breeders the author found that there is considerable variability in the progeny of supposedly pure melanistic pheasants. Some breed true, while others do not. This has lent strength to the theory that they are of hybrid origin. To find some explanation of the diverse results obtained with this form, and because it differs more radically from the type form than any of the variants found in the subspecies mentioned above, the melanistic pheasant was the first type selected for the genetic study of Phasianus.

The only data known concerning this form are those of Danforth[4] who reported on the F_1 generation following a single mating of melanistic ♀ ♀ × *P. c. mongolicus* ♂. The young were uniform with the melanistic mutant traits showing partial to nearly complete dominance. The females differed only slightly from their mothers, and males resembled mutant males but were larger in size and somewhat lighter in color and with more markings. They showed a mere trace of neck ring, or none at all.

Description

The color and color patterns of the various subspecies of *P. colchicus* are extremely complex and offer considerable difficulty in classification of either chicks or adults. The melanistic mutant is primarily black throughout, both as a chick and adult. The chick is predominantly black when hatched, although there is variation, with some individuals

showing considerable brown (Figures 6*A*, 6*B*). The throat, wing primaries or remiges, and abdomen are white with considerable variation among individuals. The adult male is a brilliant black with a blue-green and purple sheen, particularly around the neck and hackle. The tail feathers are barred. The female is black, but shows some signs of brown barring in most individuals.

The ringneck, or common pheasant, is well known but presents such a variety of colors that it is difficult to describe. A brief description from Chapman[3] is as follows:

> The male of the ringnecked pheasant has the head and neck green with strong purplish reflections; a more or less complete white neck-ring; rump gray or yellowish gray; breast bronze-red, the feathers very narrowly margined with purple-black; the ends of the feathers notched and with a narrow purple-black wedge; flanks buffy, tipped with blue-black. The females are mixed-black, brownish and rusty above, below brownish yellow, the breast and sides with rust and black.

At hatching the chicks resemble those of the domestic Brown Leghorn fowl. The under parts are sandy buff and the back, head and neck are somewhat more brown, with three black stripes on the back (Figure 6*C*).

Genetic Analysis

The first crosses were made in 1935. A male and six female melanistic pheasants were obtained and reciprocal crosses were made with ringnecks. The male, A-5, was mated with ringneck females and the six melanistic females were mated to a single ringneck male, A-15. The latter cross, using four of these original melanistic females, was repeated with ringneck male, B-24, in 1936. Classifications of the chicks at hatching were as follows:

	Melanistic	Ringneck
Melanistic ♂, A-5 × ringneck ♀♀	46	44
Ringneck ♂, A-15 × melanistic ♀♀	22	25
Ringneck ♂, B-24 × melanistic ♀♀	27	33
Total	95	102

Since none of the melanistic females produced only melanistic or only ringneck chicks, and all were evidently heterozygous for a single gene inducing melanism, their families have been grouped together in this summary.

All of the chicks classified as ringnecks were striped and unmistakably identical with chicks of pure ringnecked pheasants, but the melanistics varied considerably. Their colors ranged from a light chocolate brown to black, but striping was seen on only a few of the lightest chicks and then but faintly. White markings in varying degrees on the head, throat, wing tips and abdomen were common to all the melanistic chicks, but absent from the ringnecks. The amount of white marking was independent of the ground color (Figures 6*A*, *B*, *D*). The distinction between the two types was quite sharp, and in no case was there any doubt whatever of the correct classification. The variation among these F_1 melanistic chicks was greater than that usually seen in pure stock of that pheasant, but since subsequent analyses showed that they were apparently all heterozygous for a single gene producing melanism, such variation is not surprising.

At maturity the chicks classified at hatching as ringnecks proved to be indistinguishable from normal ringnecked birds. This applied to both sexes. On the other hand the F_1 melanistic chicks developed into adults readily distinguishable from ringnecks and also from typical melanistic pheasants (Figure 5*C*). The differences were particularly noticeable in males. In these the markings, or feather patterns, of the hybrids did not resemble those of the ringneck except in the anterior portion of the back, the scapulars, wing coverts and secondaries. Whereas the breast is bronze-red in ringnecks, it is greenish-black in the hybrids. In females the light brown colors of the ringneck were replaced in the melanistic hybrids by darker shades. The differences between these hybrids and ringnecks were so marked that neither form could possibly be mistaken for the other.

In comparison with melanistic pheasants which approach the breeder's ideal, the adult hybrids exhibited less intense

MELANISTIC AND NORMAL RINGNECK CHICKS

Figure 6

Melanistic chick (*A*), with ground color of light and dark chocolate brown and lacking white markings, compared with a common Ringneck pheasant chick (*C*). The melanistic phase in combination with white markings is shown in the two other chicks—(*B, D*). These combinations were found in F_1, F_2, and backcross progeny.

melanism. The females of that group were brownish in color rather than the black-brown of typical melanistic females. In some of the hybrid males there were traces of the white neck-ring, characteristic of ringneck males. The hybrid males also differed from typical melanistics in having an incomplete extension of black to all regions of the plumage, and traces of ringneck feather patterns mentioned in the previous paragraph.

A striking revelation of this first cross was the remarkably close resemblance of the plumage color and pattern of the adult melanistic hybrids to pheasants of the species *P. versicolor*. This is of special interest because of the belief among some pheasant breeders that the birds commonly called melanistic mutants originated from *P. versicolor*.

The fact that none of the melanistic birds used in the crosses reported above produced only melanistic offspring, coupled with the 1:1 segregations obtained in all matings, indicated that

all of the supposedly pure melanistic pheasants with which the experiment was begun were heterozygous for an incompletely dominant gene inducing melanism. Subsequent tests confirmed these indications and the symbol *M* is assigned for this gene. That it is autosomal is shown by the cross, melanistic ♀ ♀ × ringneck ♂, which produced melanistic birds of both sexes in approximately equal numbers.

It was difficult to obtain melanistic females known to be pure, but a good male with very intense pigmentation was finally secured. When this male, B-60, was crossed with six ringneck females, 80 F_1 chicks were obtained, all of which were melanistic. Their down color ranged from brown to black, with white markings as before. Since no chicks of the ringneck type appeared in this generation, ♂ B-60 was proven homozygous for melanism. At maturity these F_1 chicks were all of the intermediate melanistic type described above.

F_2 Generations

In 1936 intermediate melanistic females (*Mm*), from the original 1935 mating of ringneck ♂ A-15 × heterozygous melanistic ♀ ♀, were mated to an intermediate male (*Mm*) from the reciprocal cross to produce an F_2 generation. A similar mating was made in 1937 by mating *inter se* the F_1 progeny from ♂ B-60. Classifications at hatching were as follows:

	Melanistic	Ringneck
1936	40	14
1937	96	27
Total	136	41
Expected	133	44

Taken together these matings yield good fit to the 3:1 ratio expected of a recessive character in the F_2 generation. Considering the marked phenotypic differences between the *Mm* and *mm* genotypes and between the heterozygotes and typical melanistics, it was expected that in the F_2 generation it would be possible to distinguish *MM* and *Mm* birds. However, of the F_2 pheasants reared to maturity all were intermediate melanistic and none showed complete extension of black to all regions of the plumage, as did ♂ B-60. This indicates that, while a single major gene differentiates the melanistic pheasant from the ringneck, maximum expression of the character *M* is dependent upon modifying genes which have apparently accumulated in the melanistic as a result of selection.

The variability of the melanistic chicks is shown by the following distribution of variant forms found in the F_2 generation:

Normal, ringneck (Fig. 6*C*)	27
Brown, very little white (Fig. 6*A*)	19
Brown, extensive white markings	23
Black, very little white	3
Black, extensive white markings (Fig. 6*D*)	27
	99

These striking differences disappeared entirely before maturity. No relationship between color of down and sex was found.

Backcrosses

While the matings of the original stock secured in 1935 turned out to be backcrosses of heterozygotes to the recessive form, it was felt desirable to make further tests with the progeny of the homozygous ♂ B-60. Accordingly, backcrosses of F_1 intermediate melanistic females were made to ♂ B-60 and to a ringneck male. An intermediate melanistic male, ♂ B-72, from the 1935 matings was also backcrossed to ringnecks.

	Melanistic	Ringneck
F_1 ♂ × ringneck ♀ ♀	75	74
F_1 ♀ ♀ × ringneck ♂	18	15
♂ B-72 × ringneck ♀ ♀	39	36
	132	125
F_1 ♀ ♀ × melanistic ♂ B-60	89	0

The 89 backcross chicks hatched from ♂ B-60 had much the same appearance as the heterozygotes hatched in other matings and showed almost as much variation, but, in general, were somewhat darker. As they developed it was noticeable that many of them had much more intense melanism and a more complete extension of black than had any of the

F_1 melanistic pheasants from other matings (Figure 5*D*). Among those reared to maturity it was possible to distinguish between particularly dark birds, probably homozygous for *M*, and the intermediate phenotype of the heterozygote, but, since these intergraded considerably, no attempt was made to estimate in this population the ratio of homozygotes to heterozygotes.

Discussion

It is evident from the material presented that melanism in Phasianus is dependent upon a single autosomal, incompletely dominant factor, *M*. The data indicate that the ringneck pheasants used in the matings carry modifying factors which restrict the extension of melanism to certain parts of the plumage in birds heterozygous and homozygous for *M*. The true melanistic pheasant apparently lacks such modifiers or carries genes extending black.

This analysis will explain to a considerable degree the occurrence of strains of melanistic pheasants which do not breed true in the hands of the game breeder. The appearance of ringneck progeny from supposedly pure melanistic stock probably depends on the fact that it is practically impossible to distinguish *MM* from *Mm* birds among the breeders. This applies particularly in the case of the melanistic females but is also applicable to the males. Apparently the breeders of melanistic pheasants have consistently selected for a greater extension of black, but, inasmuch as the progeny test is not used, it is impossible to eliminate completely the individuals heterozygous for melanism, or which carry various combinations of the modifying factors.

As to the possible origin of this pheasant, it cannot yet be definitely stated whether it resulted from mutation or from hybridization of *P. versicolor* with *P. colchicus* followed by selection for increased melanism.

The resemblance of the M*m* males (and indeed of nearly all melanistic males in the F_2 generation) to typical specimens of *P. versicolor* is remarkable. The marking and general appearance are alike except that where the versicolor is dark green the dark birds extracted from mutant × ringneck cross are blackish. The latter do show considerable green in some cases. This suggests that the typical intensely black melanistic pheasant of the fancier is genetically like the versicolor, but cannot show the pattern of the latter because of the accumulation of modifying genes which increase the melanism and extend black color to all parts of the plumage.

If further genetic analyses prove this hypothesis to be correct, the mystery of the origin of the melanistic mutant will then be somewhat clarified. Since *P. versicolor* is in nature restricted to the islands of Japan, while *P. colchicus* and its subspecies are distributed over a large part of continental Asia, it seems probable that the *colchicus* type is the older form, *i.e.*, the "wild type" of the geneticist. If in some of these birds in Japan there occurred a dominant mutation to melanism it would probably spread through the Japanese archipelago, unless it adversely affected the survival of the heterozygotes. In the absence of artificial selection there would be no accumulation of genes intensifying melanism. On the contrary it is not improbable that natural selection would tend to eliminate such modifiers by favoring the less melanistic birds. Under these conditions and because the *M* gene is dominant, one would have in time a population differing from the original *colchicus* birds sufficiently to be labelled by many ornithologists as a separate species, *P. versicolor*.

Following introduction of such birds into the aviaries of Europe, they were released into the game coverts and crossing with the ringnecks inevitably followed. Any descendents showing more melanism than the original versicolors could serve as progenitors of what are now called the melanistic mutants. This hypothesis is supported by the description and photographs of the earlier melanistic pheasants, which clearly showed more color patterns and less black than their descendants of today. The latter undoubtedly owe their perfection in the

accumulation over the past 50 years of modifying genes which enhance the melanistic effect, and to elimination of modifiers which prevent maximum expression of the *M* gene.

Proof of this hypothesis must await genetic analysis of the versicolors. Seth-Smith[19] has reported that offspring of the cross *P. versicolor* × *P. colchicus* are not identical with the melanistic form but his analysis was not carried beyond the F_1 and the details given are meager.

The discovery by Momiyama and Kumagai[17] of three melanistic females of *P. versicolor* on the island of Hondo, Japan, is not incompatible with the hypothesis just given. Mutations could occur in nature similar to those which have been preserved under domestication by the fancier to heighten the melanistic effect in his black pheasants.

Summary

Melanism in the genus Phasianus is due to a single, autosomal, incompletely dominant factor, *M*. This is shown by the ratios observed in 254 F_1, 197 backcross and 177 F_2 pheasants following crosses involving melanistic and ringneck pheasants.

Birds heterozygous for *M* resemble closely pheasants of the species *P. versicolor*.

Theories relative to the origin of the "melanistic mutant" pheasants and the possible relation of these birds to *P. versicolor* are briefly discussed.

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Crime Skeletons in the Bavarian Closet

FOLLOWING up the offspring of 93 Bavarians condemned for crimes of violence, Dr. Arnst reports* that 56% of their sons over 20 years of age had been convicted of crime,—27% of them more than three times each. Of their daughters over 20, 23% had been convicted. The worse the record of the father (and also of the mother), the worse was likely to be the record of the children. Dr. Ernst analyzes the background and history of these (giving case histories in detail), but does not attempt to decide how much of the criminal behavior is conditioned by environmental factors.

Paul Popenoe.

*UEBER GEWALTSTAETIGKEITS-VERBRECHER UND IHRE NACHKOMMEN, by Konrad Ernst. 10 illus., pp. 142, price RM. 19.70. Berlin, Julius Springer, publisher, 1938.

INHERITANCE OF ABSENCE OF THUMB NAILS

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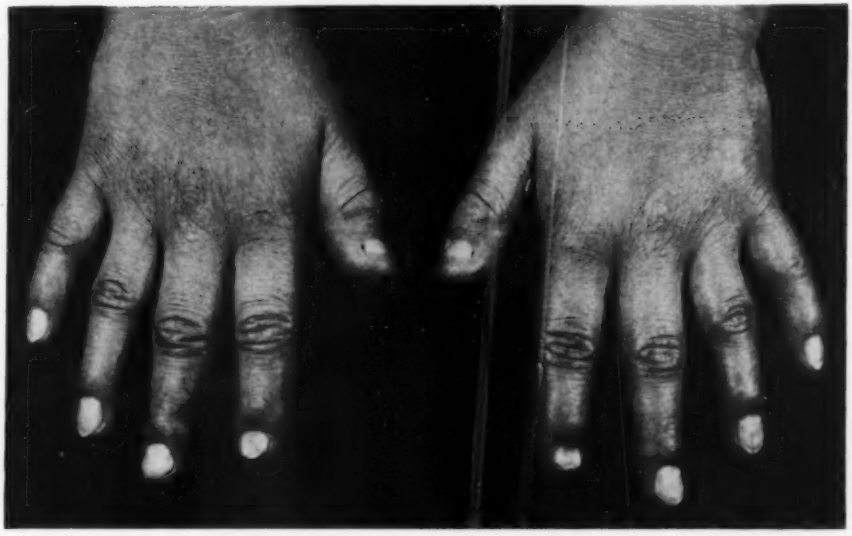


THUMB NAILS FAIL TO DEVELOP

Figure 7

Hands of a young woman showing the complete absence of thumb nails and slight abnormalities of the nails of the other fingers.

RECENTLY the writer's attention was called to the complete absence of nails on the thumbs of a young woman. As is evident from Figure 7, a glance at her hands does not reveal the lack of thumb nails, because the nail bed on each thumb is normally developed and demarcated and gives the impression of a nail, but a closer inspection makes it apparent that no cornification is to be found. The rest of her fingers possess nails but some of them are slightly abnormal. This abnormality varies in degrees from the index to the little-finger. The nail of each index-finger is thin, and, according to the young woman's statement, grows very little. The nails of the rest of her fingers are abnormal primarily in that they show unusually large and pointed lunulae.

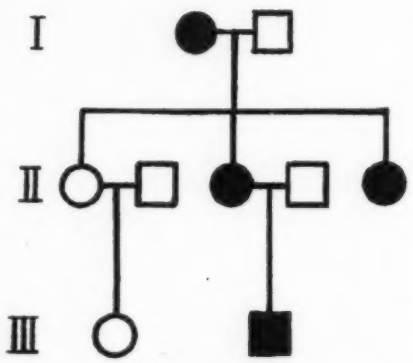
The young woman's hands also deviate slightly from the normal in being short. This apparently is due not only to short phalanges but to short metacarpals as well. The finger joints seem normally flexible with the exception of the distal joint of each ring-finger. These the girl can flex only a few degrees.

Inquiry regarding members of the young woman's immediate family revealed that her mother's, one of her two sister's, and her nephew's hands

are also affected. Her mother was an orphan and nothing is known of her ancestry. The records, therefore, can not be extended farther back. The mother's thumbs are entirely without nails, and the nails on the rest of her fingers show the large and pointed lunulae that are apparent on the nails of the propositus. The affected sister's thumbs do not lack nails completely but the cornification on them is very meager. Only a small thin scale is present at the base of each thumb nail bed. The rest of her fingernails are normal in shape but show the large and pointed lunulae. The nephew who at this writing is only one and a half years old apparently had normal finger nails at the time of his birth. According to his mother's statement his thumb nails began to show the anomaly when he was a year old. When recently examined by the writer his thumb nails were barely visible as small thin plates at the base of the nail beds. As regards the rest of his nails nothing very definite can be said, but there is some indication that they will eventually show the pointed lunulae.

Although the pedigree that is presented is not very extensive it seems fairly certain that the anomaly involved has a genetic basis. Whether the causal factor is transmitted through the cytoplasm or in a chromosome as a Mendelian unit the data do not permit us to say, but one is tempted to suggest that the latter is the case and that one dominant gene is responsible for the major part if not all of the effect.

A pedigree of the complete absence of thumb nails has previously been reported by Osterreicher.[1] This also suggests that a dominant gene is the causal factor. It is not very probable, however, that the two occurrences represent the same mutation, because they show some differences in their phenotypic expressions. Osterreicher found that members of his pedigree who lacked thumb nails also tended to lack patellae. This does not appear to hold true for the affected members of the present pedigree. The same correlation, however, was observed by C. M. Little[2] in his studies on the inherited absence of patellae.



THREE GENERATIONS OF DEFECTIVE THUMB NAILS

Figure 8

Pedigree of a family showing the absence of thumb nails and slight abnormalities of the other finger nails.

In addition to the pedigrees already mentioned a number of isolated cases of anonychia have been reported. Some of these may have had a genetic basis but most of them are reported to have been the result of disease of one type or another.

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2. Little, E. M. Congenital absence or delayed development of the patellae. *Lancet*, Volume 2 for 1897, pp. 781-794. 1897.

SEXUAL DIMORPHISM IN DOWN AND ADULT PLUMAGE OF THE PILGRIM GOOSE

JOSEPH P. QUINN

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IN a recent article, Gordon[2] has described a sexual color dimorphism in a variety of geese found in Alabama. He states that, "the males have a solid white plumage except for an occasional grey feather, whereas the females are mostly grey or parti-colored with white areas on the head, breast, and ventral regions. The down color of the goslings is either light or dark grey, ... the lighter ones develop the white plumage of the male, while the darker ones assume the grey of the female."

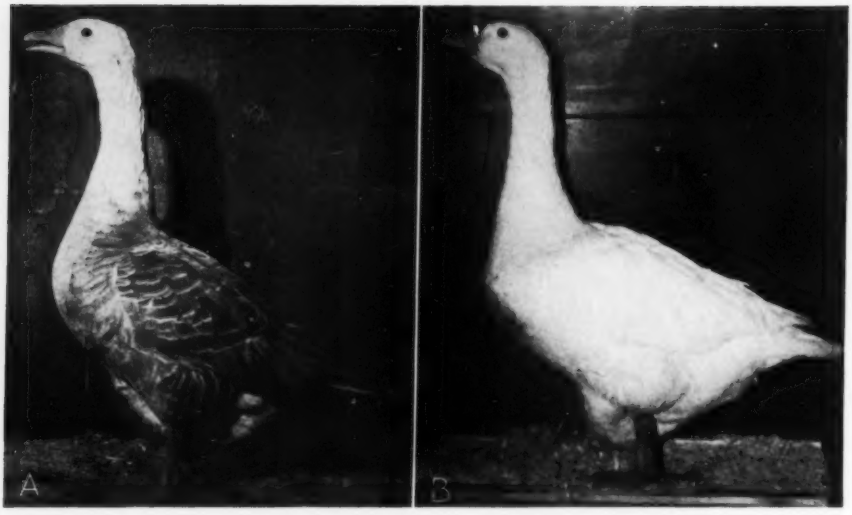
In discussing the sexual dimorphism in the adult plumage he states that "such a condition is rare among domestic birds." This statement does not agree with the fact that a relatively large number of breeds and varieties of chickens and ducks are described as sexually dimorphic in the American Standard of Perfection. Although none of the six American Standard breeds of geese are sexually dimorphic there are three breeds of European geese which show a sexual color dimorphism in the adult plumage. Two of these breeds, the Padovarna and Pomeranian, have been described by Brown,[1] the ganders being gray or parti-colored and the geese white. According to Robinson,[4] Normandy geese have a sexual color dimorphism in the adult plumage similar to that found in the geese described by Gordon. The common geese of England and Colonial America are said to have been derived from the Normandy geese.

Robinson[5] lists the Normandy geese among other French breeds and states that although the Toulouse geese are the most popular, there are several local breeds of importance in parts of France. He further states: "The Normandy geese resemble the common geese of England and America before the introduction of the Emden and Toulouse. The females are gray and white; males mostly white."

The Normandy geese, or the common geese derived from them, were quite popular during Colonial times because of the easy identification of the sexes at any stage of development. Their popularity decreased with the introduction of such larger and more prolific breeds as the Emden and Toulouse, although there were no easily distinguishable sex characteristics in the latter breeds.

During recent years an attempt has been made to revive the popularity of the sexually dimorphic geese among a few breeders in several sections of the United States. As it is believed that they were the earliest known domestic geese kept in the United States, the breed designation of "Pilgrim" geese was given them, the breed organization being known as the Society of the Pilgrim Goose.

Grow[3] has given a detailed description of the Pilgrim geese which appears to agree essentially with that given by Gordon[2] of the Alabama geese, and, in general, with the Normandy geese which have a similar dimorphism in the adult plumage. Grow states that the down color of the ganders "may show considerable gray but they may then be distinguished by their light colored bills; whereas the female goslings resemble the Toulouse at hatching time, their down being a darker shade and their bills dark." The



SEX DIFFERENCES IN PLUMAGE

Figure 9

A three-year-old Pilgrim Goose with white head and neck (*A*), which appears to be an age dimorphism in this type of goose, and a three-year-old Pilgrim Gander (*B*).

adult gander is said to be pure white in plumage although most of the young ganders show a tinge of gray in the wings, over the rump, and in the tail feathers, until they have undergone their first molt. The females, on the other hand, are a light ashy gray with more or less white about the head and abdomen. The white in head of the female is believed essential, as females not possessing it may produce ganders with some gray in plumage. The eye color of the adult gander is blue, that of the adult goose being brown or hazel. The body weights are given as from eight to ten pounds. The annual egg production in unselected specimens is stated to be about 12 eggs and frequently not more than eight to ten. In type it is described as similar to that of the Embden, being without dewlap.

Pilgrim geese were exhibited at the Northeastern Poultry Producers Exposition in 1937 and 1938. An exhibitor stated that the white in the heads of the females tended to increase with age, but that the neck of the young goose may be almost entirely gray up to and beyond six months of age. Figure 10 shows a six-months old goose with gray neck and small areas of white around the eyes. In Figure 9*A* a three-year-old goose is shown with an entirely white head and neck, which appears to be an age dimorphism in this type of goose. In the photo of the goose shown by Gordon[2] the head and dorsal portion of the neck are white, the remainder of the neck being gray. Figure 9*B* is a photograph of a three-year-old Pilgrim gander.

The Alabama geese described by Gordon[2] seem to have the same characteristics in down and adult plumage, in adult eye color, and in body type and weights, as the Pilgrim geese described by Grow[3]; their historical predecessors, the common geese of colonial America and England, and the Normandy geese of France. The sexual dimorphism in eye color of the adult Alabama geese is apparent in the specimens of Pilgrim geese exhibited. How-

GRAY NECK PHASE

Figure 10

A six months' old Pilgrim Goose with a gray neck.

ever, breeders of Pilgrim geese state that the blue eye found only in adult birds by Gordon[2], may also be found in young males. The similarity between the Alabama geese and the Pilgrim geese probably indicates a common origin. The Alabama geese may have been derived from Normany geese brought to Louisiana by early French settlers. They may also have been imported by New England breeders, who found homes in the South at a later period. A leading breeder and exhibitor of Pilgrim geese, now living in Missouri, states that he kept a flock of these geese 45 years ago, as a boy in Vermont. The possibility of migration may also receive consideration, as the Pilgrim geese, unlike most domesticated geese, can fly quite well.

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2. Gordon, C. D. Sexual Dimorphism in the down color and adult plumage of geese. *Jour. Hered.* 29:335. 1938.

3. Grow, Oscar. The Pilgrim Goose. Cackle & Crow. New Haven, Mass. March 15, 1935. p. 12.

4. Robinson, J. H. The growing of ducks and geese for profit and pleasure. Reliable Poultry Journal Pub. Co., Dayton, Ohio. 1924. p. 300.

5. ————. Popular breeds of domestic poultry. Reliable Poultry Journal Pub. Co., Dayton, Ohio. 1924. pp. 324-325.

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Submarginal Farm Families in the United States

A recent study of the "sore spots" in rural areas of the United States discloses the major factors tending to reduce about one-third of the Nation's farm population to standards of living which are "submarginal." A summary of the findings of the study is given below:*

In 1929 the farms in the United States with a gross income of less than $600 per annum, based on value of used, traded, and sold products, numbered about 1,700,000, of which slightly over 900,000 had a gross income of a little less than $400 and almost 400,000 a gross income under $250. The lives of about 7,700,000 men, women, and children on these 1,700,000 farms were disadvantageously affected by lack of purchasing power.

Among the gainfully employed workers in agriculture in 1930 about 2,700,000 were hired farm laborers. A large, and an apparently growing number of such laborers are destined never to rise above this status.

In 1935 the number of tenant families on farms in the United States aggregated 2,865,000, constituting a population of about 13,000,000, of whom over 700,000 were sharecroppers with a status scarcely above that of hired laborers.

The land of more than 500,000 of the Nation's farms is so poor that it means actual starvation for those families dwelling on it, if they continue to attempt to make a living by farming these holdings.

About 3,000,000 persons move annually from farms to cities and towns or from towns and cities to farms. Each year more than 1,000,000 farm families move from one farm to another. This very great mobility among the farm families of the United States is indicative of the constant efforts of hundreds of thousands of farm families to find greater economic opportunities.—*Labor Review.*

*Disadvantaged Classes in American Agriculture. By Carl C. Taylor, Helen W. Wheeler, and E. L. Kirkpatrick. U. S. Department of Agriculture, Washington, 1938.

SEVENTH INTERNATIONAL CONGRESS OF GENETICS

Edinburgh, Scotland, 23rd-30th August, 1939

THE Seventh International Congress of Genetics is to be held in Edinburgh, Scotland, on the 23rd-30th of August, 1939. The Committee of the Genetical Society of Great Britain is responsible for its organization. There are to be seven main sections each with its Recorder and Secretary, and the officers of these sections constitute the Congress Organizing Sub-Committee. The *General Secretary* is Professor F. A. E. Crew, Institute of Animal Genetics, West Mains Road, Edinburgh, 9, Scotland. Messrs. Pickfords Travel Service, 18 South St. Andrew Street, Edinburgh, 2, are the official travel agents for the Congress.

The membership subscription is Two Guineas (£2:2:0), which includes the cost of a copy of the Proceedings of the Congress. Accommodation is being provided in hotels, (for rates see attached list) and in University hostels (380 beds) at the rate of £3:3:0 for the period (plus ten per cent for staff). Correspondence concerning accommodation should be addressed to the General Secretary of the Congress.

The outstanding consequence of the 1927 Berlin Congress was the impetus given to the work on the induction of mutation by means of X-rays: that of the 1932 Ithaca Congress, the final amalgamation of cytology and genetics and the emergence of physiological genetics. It is hoped that out of the proceedings of the Edinburgh Congress there will arise a clearer understanding of the needs for and the means of harnessing genetics to agriculture, medicine and sociology.

The programme is, of course, not yet complete; its structure must necessarily be affected by the papers yet to be offered. At the present moment some 350 geneticists from different parts of the world have intimated their intention of coming and have offered papers for presentation. It is intended to give particular prominence to the application of Genetics in Livestock and Plant Breeding (Sections D and E) and for this reason it is hoped that those countries in which work of this kind is being actively prosecuted will be strongly represented.

The sectional programs as they at present stand include the following organized discussions:

A. Gene and Chromosome Theory

Recorder: Dr. H. J. Muller, Institute of Animal Genetics, West Mains Road, Edinburgh, Scotland.

Secretary: Mr. D. G. Catcheside, Botany School, The University, Cambridge, England.

(Joint sessions with Section B.)

B. Cytology

Recorder: Dr. C. D. Darlington, John Innes Horticultural Institution, Mostyn Road, Merton Park, London, S. W. 19.

Secretary: Dr. P. C. Koller, Institute of Animal Genetics, West Mains Road, Edinburgh, Scotland.

Gene mutation; Structural changes in Chromosomes; Positional effect; Protein and virus studies in relation to the problem of the gene; Salivary Gland studies; Mechanism of crossing-over; Chromosome structure.

C. Physiological Genetics

Recorder: Dr. Boris Ephrussi, Inst. de Biologie Physico-Chemique, 13 Rue Pierre Surie, Paris V, France.

Secretary: Mr. C. H. Waddington, Christ's College, Cambridge, England.

Cytoplasmic inheritance; Genes and hormones; Sex; Genetics and embryology; Genetics and biochemistry; Genetics and physiology.

D. Animal Breeding in the Light of Genetics

Recorder: Dr. A. D. Buchanan Smith, Institute of Animal Genetics, West Mains Road, Edinburgh, Scotland.

Secretary: The Imperial Bureau of Animal Genetics, West Mains Road, Edinburgh, Scotland.

The inheritance of productive qualities in livestock; Application of statistical analytical methods to genetical problems affecting livestock; the planning and conduct of a genetical experiment with slow breeding animals; Artificial insemination; the inheritance of specific characters of livestock; Livestock improvement in the Tropics; the function of the State in livestock improvement.

E. Plant Breeding in the Light of Genetics

Recorder: Dr. K. Mather, The John Innes Horticultural Institution, Mostyn Road, Merton Park, London, S. W. 19.

Secretary: Dr. S. Ellerton, School of Agriculture, Cambridge, England.

Genetics and the production of improved crops; Methods of plant breeding; Genetics of cereals and grasses; Plant cytogenetics; Disease and vigour.

F. Human Genetics

Recorder: Professor G. Dahlberg, State Institute for Human Genetics and Race Biology, University, Uppsala, Sweden.

Secretary: Dr. L. S. Penrose, Research Dept., Royal Eastern Counties Institute Ltd., Colchester, England.

Natural selection in man; Genetics of human populations; Linkage in man; Inheritance of mental disorders.

G. Genetics in Relation to Evolution and Systematics

Recorder: Dr. J. S. Huxley, F.R.S., Zoological Society of London, Regent's Park, London, N.W. 8.

Secretary: Dr. W. B. Turrill, The Herbarium, Royal Botanic Gardens, Kew, Surrey, England.

Comparative genetics and evolution; Experimental and wild populations; Microevolution; Hybridization; Polyploidy; Reproductive mechanisms.

Sub-Sections

H. Statistical Genetics

Recorder: Professor R. A. Fisher, F.R.S., The Galton Laboratory, University College, Gower Street, London, W.C. 1.

Secretary: Mr. F. Yates, Rothamsted Experimental Station, Harpenden, Herts.

This sub-section was created in order that its members might come to the aid of the sections of Animal Genetics and Plant Genetics in the staging of discussions involving the application of statistical methods to the problems of Animal and Plant Breeding. It is hoped to arrange for a special discussion on the teaching of statistics to students of genetics.

I. The Genetical Aspects of Growth, Normal and Abnormal

Recorder: Dr. C. C. Little, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine, U. S. A.

Secretary: Dr. Alex. Haddow, The Research Institute, The Royal Cancer Hospital, Fulham Road, London, S.W. 3.

It was decided that it would be desirable to organize a group that would deal thoroughly and comprehensively with the genetical aspects of tumour growth. Cancer will of course figure largely in the discussions of this sub-section but in addition the genetical aspects of growth in general will be considered.

Smaller specialist groups will be organized for round-table discussions on such matters as poultry genetics, fox genetics, cotton, wheat, and rubber genetics, etc. It is hoped to attract to the Congress research workers in different parts of the world who are concerned with the breeding and improvement of the same animal or plant of economic importance. It is hoped that the contacts made at meetings and discussions will be of mutual benefit to them.

Tours

A Pre-Congress tour from London to Edinburgh by motor bus has been arranged. The party will meet in London on Tuesday, 15th August. Wednesday and Thursday will be spent in visiting various University Departments and Research Institutions. On Friday the party will move to Cambridge by motor coach, there to spend the afternoon and the whole of Saturday in visiting the University Departments, Colleges and Research Institutions. On Sunday the party will leave for Chester, travelling through typical English scenery to reach this city steeped in historic associations. On Monday the journey will end at Windermere, the center of the English Lake District. On Tuesday the party will cross the Border at Carlisle, travel through the border hills, and reach Edinburgh in the late afternoon.

Further details concerning the Pre-Congress tour, inter-Congress tours and post-Congress tours are given in the attached notices.

Social Functions

During the Congress week a number of social functions have been arranged: e.g., Reception by the City of Edinburgh; Congress Banquet in the Library Hall of the University; visits to Art Galleries, Museums, and places of historic interest, etc.

Itinerary for Pre-Congress Tour

Tuesday, 15th August

London. Evening Reception.

Wednesday, 16th August

London. Alternative excursions by motor coach.

Rothamsted Experimental Station. 4/6 per head for multiples of 20 persons (exclusive of lunch).

East Malling Research Station; do.

Whipsnade Zoo. 10/- per head for multiples of 20 persons. (Exclusive of lunch).

Morning sightseeing tour of London including admission and services of guide lecturer. 4/6 per head.

Half day tour to Windsor Castle, Eton College and Hampton Court Gardens. 6/- per head.

Thursday, 17th August

London. Short excursions, singly or combined to Gardens and Laboratores of the Royal Horticultural Society, Wisley (by motor coach) 4/- per head.

Botanical Gardens, Kew; Zoological Gardens, Regent's Park; John Innes Horticultural Inst.; College and Museums, either by ordinary transport or by special buses.

ALTERNATIVE EXCURSIONS

Morning sightseeing tour of London (see above).

Half day tour to Windsor Castle, etc. (see above).

Friday, 18th August

Leave London by motor coach for Cambridge.

Saturday, 19th August

Cambridge. Visits to Colleges and Research Institutes, etc.

Sunday, 20th August

Leave Cambridge by motor coach via Huntingdon, Northampton, Leamington, Warwick, Stratford-on-Avon, Droitwich, Kidderminster, Shrewsbury, Whitchurch, Chester.

Monday, 21st August

Continue journey North via Mersey Tunnel, Liverpool, Southport, Preston, Lancaster, Kendal, English Lake District, Windermere.

Tuesday, 22nd August

It is hoped to visit Wray Castle, Fresh Water Biological Station, then continue through the Lake District to Grasmere and Keswick, Bothel, Carlisle, and thence into Scotland; along the valley of the Annan to Moffatt, over the Devil's Beef Tub, Peebles, arriving in Edinburgh in the late afternoon.

It is impossible to quote a flat rate for that part of the tour actually spent in London as different persons will be arriving at different times and undoubtedly will choose to do different things whilst in London. The inclusive cost for the journey From London on Friday, 18th August, to Edinburgh, on Tuesday, 22nd August, will be £7:10:6d per head for a minimum of 20 persons. This will include for this period:

Up-to-date saloon motor coaches,

Luncheons,

Accommodations consisting of dinner, bed and breakfast, at best available hotels,

Gratuities to hotel servants and services of a Pickfords Representative to each two coaches to supervise the whole of the arrangements.

Suggested Post-Congress Tours

1. Oban, Five Highland Lochs, and Iona: 2 nights in Oban.
   3 Days: £5. inclusive.
2. Aberdeen, Loch Ness and Glencoe: nights in Aberdeen, Inverness and Fort William.
   4 Days: £6.10.0.
3. Western Highlands and Isle of Skye: nights in Fort William, Flodigarry (2 nights), and Inverness.
   5 Days: £10.0.0.
4. Grampians, John o' Groats, Loch Ness, and Glencoe: nights in Inverness, Thurso, Bonar Bridge, Strathpeffer and Fort William.
   6 Days: £10.10.0.
5. Caledonian Canal and Kyles of Bute tour by rail, steamer and motor coach: nights in Aberdeen, Inverness and Oban.
   4 Days: £7.0.0.

Note: Additional information about hotel rates in London, application forms for Pre-Congress Tour (must be submitted by June 16 next), Hotel Accommodations at Edinburgh (£3.3 - £8.15 per week), etc., will be furnished on application to the A. G. A. office, 308 Victor Building, Washington, D. C.

Dr. E. W. Lindstrom, in charge of American Travel Arrangements, writes that there will be a special sailing of geneticists on the *Georgic* of the Cunard White Star, leaving New York August 5 for Cobh, Southampton, Havre and London. Arrangements for this sailing as well as for all tours arranged for Congress participants abroad may be made with the Allen-Harms Travel Service, 509 Welch Avenue, Ames, Iowa. The American Express Company, 65 Broadway, New York City, also has issued a Genetics Congress travel announcement.

VARIATIONS IN THE NUMBER OF VERTEBRAE OF SWINE*

V. A. FREEMAN

OBSERVATIONS have shown that pigs vary in the number of ribs and that extra ribs usually are associated with extra body vertebrae and longer-bodied pigs. The length of two of the most popular cuts from the American type hog, loins and sides, are directly affected by length of body. Ham is the only cut that exceeds their usual value per pound. If hams, feeding quality and body balance could be maintained and longer bodies produced, it would appear that the cut-out value of the carcasses might be increased by selecting for extra ribs and body vertebrae.

A. M. Shaw[1] reports the rib counts on a large number of hogs of the popular breeds in America and smaller numbers of hogs from other countries. He found variation in the number of ribs in almost every breed. With some breeds the smaller number of ribs seems to predominate while with other breeds, particularly the bacon type breeds and those of longer and growthier type, the larger number of ribs occurs more frequently. Wide variation frequently occurs between pigs of the same litter and is common to both sexes. The variations reported ranged from 13 to 17 pairs of ribs. He found no variation in the cervical or sacral vertebrae. The number of pairs of ribs varied with the number of thoracic vertebrae and occasionally there was variation in the lumbar vertebrae. It appears that the combined count of thoracic and lumbar vertebrae would be the factor determining the length of the body if the length of the body is affected by the number of body vertebrae.

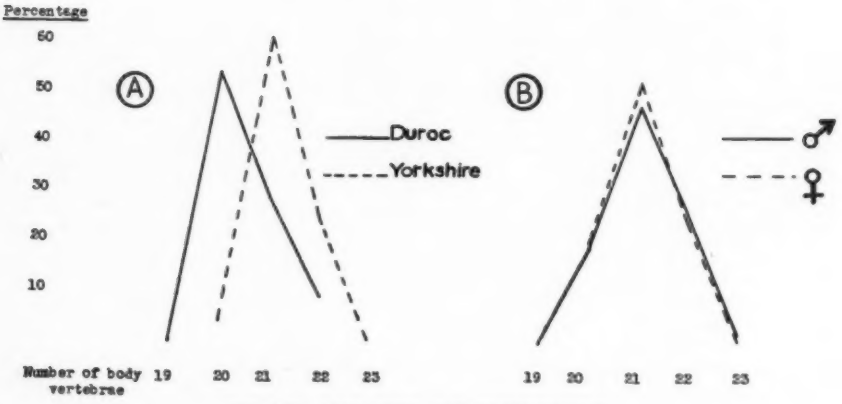
A method of determining the variations in the vertebral column of the live pig by X-ray photograph was also described by Shaw.[2] He showed radiographs of the skeletons of pigs that would enable one to make an accurate record of the number of vertebrae in live pigs. Pictures of breeding sows were shown, one sow having 17 pairs of ribs and the other sow 14 pairs. There was a noticeable difference in the length of body and type of the sows. He stated that through the use of radiographs quite large groups of pigs possessing the different vertebral variations had been selected for breeding purposes at the University of Saskatchewan farm, consisting mostly of purebred Yorkshires with some Tamworths and Berkshires.

All of the pigs that were still-born, or that died soon after birth in the Michigan State College herd, were dissected for a study of the vertebral column in the spring and fall of 1932. Observations covered the thoracic and lumbar regions and extended from the first rib back to the sacral arch. The examination was made by opening the back lateral to the backbone and exposing the skeleton sufficiently to identify the number of ribs and vertebrae. The thoracic and lumbar vertebrae will be referred to at times collectively as "body vertebrae." A total of 182 pigs were examined, including 102 males and 80 females. The observations are summarized according to breed and sex in Table 1.

Breed Differences

The occurrence of 19, 20, 21, 22 and 23 body vertebrae was reduced to a

*Journal Article No. 191 (n.s.), from the Michigan Experiment Station. The author is indebted to the Michigan Experiment Station and the Rosevale Packing Company of DeWitt, Michigan, for aid in securing data for this article, and to Dr. H. R. Hunt, Department of Zoology, for cooperation and suggestions throughout its preparation and arrangement.



BREED AND SEX DISTRIBUTIONS

Figure 11

Number of body vertebrae for (*A*) Duroc and Yorkshire breeds, and (*B*) by sex.

percentage basis to compare the observations for Duroc Jerseys and Yorkshires. The distributions are shown by graph in Figure 11*A*. The occurrence between the two sexes for all five breeds is shown in Figure 11*B*.

Marked contrast is shown in the number of body vertebrae between the 52 Duroc and 79 Yorkshire pigs dissected. One pig with 19 body vertebrae was found among the Durocs, 29 with 20, 16 with 21, and only 6 with 22 body vertebrae. Five pigs of the Yorkshire breed had 20 body vertebrae, 50 had 21, 22 had 22, and 2 had 23 body vertebrae. The mean number of body vertebrae was 20.52 $\pm$ .067 for the Durocs and was 21.27 $\pm$ .046 for the Yorkshires. This is a significant difference; the Yorkshires exceeded the Durocs by .75 $\pm$ .081. There was no significant difference in the mean number of vertebrae found in males and females.

Other variations showing intermediate conditions and suggesting a blending type of inheritance due probably to multiple factors, were observed. One Poland China sow with 15 pairs of ribs and thoracic vertebrae and 6 lumbar vertebrae had one short extra rib on her right side only. One Yorkshire sow with 16 thoracic vertebrae and 6 lumbar vertebrae had a similar small extra rib on the right side. One Yorkshire male with 16 thoracic vertebrae and 5 lumbar vertebrae, and one Yorkshire male with 16 thoracic and 5 lumbar vertebrae each had a short last rib on the right side and a normal full-length rib on the left side. On two male and two female Yorkshires and one Poland male, the last pair of ribs in each case was about one-half the normal length. One Yorkshire male had a last pair of ribs that was about three-fourths the usual length. No attempt was made to measure these ribs because the pigs varied in size and age.

Marked variation was shown by pigs within the same litter as shown in Table II. These figures include 29 pigs dissected, and counts from X-ray photographs of 8 live pigs. The three litters represent the wider variations found and are one each of purebred Duroc Jersey, Poland China, and Chester White. A heterozygous condition of the parents of these litters is indicated, especially in the parents of the litter from Chester sow No. 33.

A study of variations was made by counting the body vertebrae in pork carcasses at a central Michigan packing plant. Practically all of the hogs were purchased from farmers within 30 miles of the plant and excluding those counted which came from the College herd, it is

believed that they represent a good random sample of the hogs being produced in central Michigan.

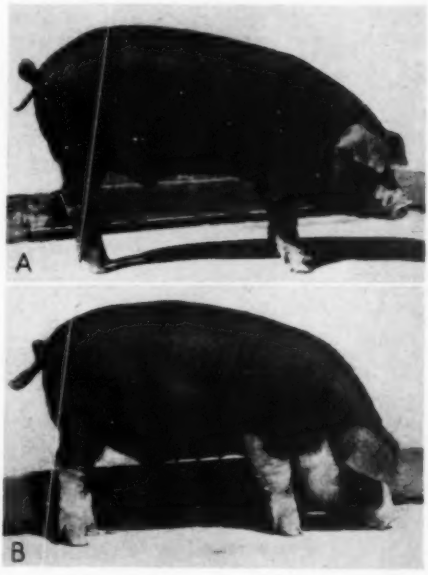
Counts were made on a total of 342 carcasses, including 107 coming from the Michigan State College herd. No attempt was made to classify these carcasses by sex or breed, and only the total number of body vertebrae was counted. The results of the counts are shown in Table III.

Only carcasses showing 20, 21, or 22 vertebrae were found. There was a significant difference in the number of carcasses with 20 and 22 body vertebrae found among the carcasses from farms and those from the College herd. Thirty-four per cent of the farmers' hog carcasses had 20 body vertebrae as compared with 7 per cent of the College carcasses. There was a difference of $.447 \pm .045$ in the mean number of vertebrae of the two groups. The difference is nearly ten times its probable error and the mathematical odds that a real difference exists are almost 65 billion to 1.

No attempt had been made to select breeding stock in the College herd with a larger number of body vertebrae, as there were no records of the number of vertebrae in the breeding herd. However, it appears that the College herd may have been more carefully selected for the present-day approved type and that the selection for relatively long, growthy hogs had resulted in a line of breeding showing a tendency toward the larger number of body vertebrae.

Some evidence that the form is modified by the number of body vertebrae is shown by the pictures of Poland barrows Nos. 26 and 2. These pictures were taken a few days before slaughter. The vertebrae were counted in the carcasses.

The vertebrae were measured individually on each of 13 carcasses, measuring from the anterior to the posterior surface of each centrum. Increased length of the body vertebrae was found proceeding backward from the first thoracic vertebra throughout the thoracic and lumbar vertebrae sections with the exception of the last two lumbar vertebrae.



CONFORMATION AND SPINE LENGTH

Figure 12

A—Poland barrow No. 2 has fifteen thoracic vertebrae and seven lumbar vertebrae. *B*—Poland barrow No. 26 has fourteen thoracic vertebrae and six lumbar vertebrae.

The lumbar vertebrae were distinctly longer than the thoracic. The average length of the vertebrae from the 13 carcasses is shown in Table IV. The average length of vertebrae in the five 21-vertebraed pigs was 1.2 per cent shorter than for the four 20-vertebraed pigs, and in the four 22-vertebraed pigs, 4.2 per cent shorter. The length of the half carcass was measured from the tip of the aitch bone (symphysis) to the anterior edge of the first rib. There was a decided tendency toward increased length of body with the increased number of vertebrae. The 20-vertebraed pigs averaged 666.5 millimeters, the 21-vertebraed pigs, 690.6 millimeters, and the 22-vertebraed pigs averaged 702.8 millimeters in length of body.

Seven carcasses with 20 body vertebrae and seven with 22 were selected at the packing plant for study by carcass

measurements. In order to find enough carcasses that would differ from one another by two body vertebrae, it was necessary to use carcasses ranging in weight from 135 to 174 pounds. However, they were selected by pairs so that when a light carcass or a heavy carcass was included in one group, a similar carcass was selected for the other group. The measurements used were selected from those worked out by the United States Department of Agriculture, Bureau of Animal Industry, and published in a mimeographed sheet entitled "Methods for Measuring Hog Carcasses".

The means of the measurements and weights of the seven pairs of carcasses are given in Table V. The carcasses with 22 body vertebrae averaged 43.7 millimeters longer than those with 20. An increase of ten per cent in the number of body vertebrae increased the length of body less than six per cent. The length of leg and depth of body were also slightly greater in the 22-vertebraed carcasses. The average depth of back fat was five millimeters less than in the shorter-bodied hogs and indicates a possibility that the longer-bodied group was not quite so well finished, which would naturally result in their being somewhat longer for the same weight of carcass.

These observations simply add to the recorded evidence of variation in the number of ribs and body vertebrae of swine. They do not prove that any material benefit would be derived from selections for the larger number, although the extra vertebrae were associated with increased length of body.

TABLE I. Variation in body vertebrae of pigs discected.

Vertebrae	Sex	Bark.	Ches.	Sacro	Poll.	Vertic.	Total
13 Thor.	M			1			1
6 Lumb.	F						
14 Thor.	M		2	16		2	21
6 Lumb.	F		1	13	1	2	17
14 Thor.	M				1	1	2
7 Lumb.	F			1		1	2
15 Thor.	M	1	2	2	13	25	44
6 Lumb.	F		2	7	6	25	44
15 Thor.	M			1	6	4	11
7 Lumb.	F	1		1	4	1	7
15 Thor.	M					4	4
6 Lumb.	F				1	4	5
16 Thor.	M	3	1	2	1	9	16
6 Lumb.	F		1	2	1	8	12
16 Thor.	M		1		1	1	3
7 Lumb.	F					1	1
Total		5	11	52	35	79	182

TABLE II. Variation in vertebrae of pigs from same litter.

		Parents		
No.Vert.	Sex	Duroc # 1	Poland # 5	Chester # 33
14 Thor.	M	2*		2
6 Lumb.	F	4	1	1**
14 Thor.	M			
7 Lumb.	F		1	
15 Thor.	M	2	2*	2*
6 Lumb.	F	2		1
15 Thor.	M	1	2	1**
7 Lumb.	F		2	
16 Thor.	M		2*	2**
6 Lumb.	F			1
16 Thor.	M			1
7 Lumb.	F			
Total		14	10	11

* 1 Pig's vert. counted from X-ray photo.
** 2 Pig's vert. counted from X-ray photo.

TABLE III. Body vertebrae in carcasses examined at packing plants.

No. vert.	20	21	22	Total	Mean	P.E.
Carc.from farms	50	134	51	235	20.749	0.039
% distribu.	34.04	57.01	8.94			
Carc.from State Col.	2	72	29	107	21.196	0.036
% distribu.	7.48	66.42	27.1			
Mean diff.					.447	0.046

TABLE IV. Length of individual vertebrae. (Av. of 13 carcasses.)

Vertebrae* Number	Thoracic (mm.)	Lumbar (mm.)
1	38.5	37.6
2	38.1	38.3
3	38.5	38.8
4	38.5	39.4
5	38.5	39.1
6	38.7	37.1
7	39.2	36.3
8	39.8	
9	39.5	
10	39.8	
11	39.4	
12	39.3	
13	39.2	
14	38.7	
15	38.1	
16	38.0	

*Vertebrae were numbered beginning at the anterior for both thoracic and lumbar groups.

TABLE V. Carcass measurements (average of 7 pairs).

Measurement in mm.	No. body vert. 20	22	Diff.
Length of body (Aitch bone to front of first rib)	743.6	787.3	43.7
Length of leg (hock of hind foot to Aitch bone)	510.6	540.6	18.
Depth of body(through chest)	343.6	351.9	8.3
Thickness of fat (average of 5 measurements on each carcass)	39.2	33.9	5.3
Width through shoulders	133.9	140.9	1.0
Width through hams	146.1	141.	- 5.1
Av. wt. lbs.	153.	158.1	- .9

TABLE VI. Length of body in carcasses with 20 and 22 body vertebrae.

Number of body vertebrae	Number of carcasses	Average length of body (mm.)	Difference
20	235	743.6	
22	51	787.3	43.7

TABLE VII. Length of body in carcasses with 20 and 22 body vertebrae.

Number of body vertebrae	Number of carcasses	Average length of body (mm.)	Difference
20	50	734.8	
22	29	778.5	43.7

Summary

Considerable variation exists in the number of ribs, thoracic vertebrae and lumbar vertebrae of pigs. Some strains of certain breeds inherit, on the average, larger numbers of vertebrae than others, but variation existed in each of the five breeds examined. The variation was about the same in each sex.

The number of ribs appear to be influenced by more than a single pair of genes.

Carcasses with 21 and 22 body vertebrae were longer than carcasses of similar breeding with 20 body vertebrae.

Evidence is presented that selection for length of body by the usual method is believed to have resulted in some increase in number of body vertebrae.

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